Starburst or AGN Dominance in Submillimetre-Luminous Candidate AGN?

Kristen Coppin*, Alexandra Pope†, Karín Menéndez-Delmestre**, David M. Alexander‡ and James Dunlop§

*ICC, Durham University, UK
†Spitzer Fellow, National Optical Astronomy Observatory, Tuscon, AZ, USA
**NSF Astronomy and Astrophysics Postdoctoral Fellow, the Observatories of the Carnegie Institution for Science, Pasadena, CA, USA
‡Department of Physics, Durham University, UK
§Scottish Universities Physics Alliance, Institute for Astronomy, University of Edinburgh, Royal Observatory, UK

Abstract. It is widely believed that ultraluminous infrared (IR) galaxies and active galactic nuclei (AGN) activity are triggered by galaxy interactions and merging, with the peak of activity occurring at $z \sim 2$, where submillimetre galaxies are thousands of times more numerous than local ULIRGs. In this evolutionary picture, submillimetre galaxies (SMGs) would host an AGN, which would eventually grow a black hole (BH) strong enough to blow off all of the gas and dust leaving an optically luminous QSO. To probe this evolutionary sequence we have focussed on the 'missing link' sources, which demonstrate both strong starburst (SB) and AGN signatures, in order to determine if the SB is the main power source even in SMGs when we have evidence that an AGN is present from their IRAC colours. The best way to determine if a dominant AGN is present is to look for their signatures in the mid-infrared with the *Spitzer* IRS, since often even deep X-ray observations miss identifying the presence of AGN in heavily dust-obscured SMGs. We present the results of our audit of the energy balance between star-formation and AGN within this special sub-population of SMGs – where the BH has grown appreciably to begin heating the dust emission.

Keywords: Starburst galaxies and infrared excess galaxies; active galaxies (AGN); redshifts
PACS: 98.54.Ep; 98.54.Cm; 98.62.Py

MAIN RESULTS

Spitzer spectroscopy has revealed that $\simeq 80\%$ of SMGs are SB-dominated in the mid-infrared ([3]; [2]). We have focussed on the remaining $\simeq 20\%$ that show signs of harboring powerful AGN and use *Spitzer*-IRS spectroscopy to study a sample of 8 SMGs $> 200\,\mu$Jy at $24\,\mu$m from the SCUBA Half Degree Extragalactic Survey (SHADES; [1]) selected on the basis of an IRAC color-selection ($S_{8\mu\mathrm{m}}/S_{4.5\mu\mathrm{m}} > 2$; i.e. likely power-law mid-infrared SEDs; see Fig. 1). The full analysis will be presented in Coppin et al. (ApJ, submitted), and our main results are as follows:

- There are signs of SF from PAH features in *all* of our SMGs, from which we derive redshifts between 2.5–3.4, demonstrating the power of the mid-IR to determine redshifts when the optical counterparts are too faint to study with current facilities.
- The IRS spectra show signs of *both* SB and AGN activity in our $S_{8\mu\mathrm{m}}/S_{4.5\mu\mathrm{m}} > 2$ SMG sample, with a continuous distribution of AGN fractions in the mid-IR.

Overall, SMGs selected in this way tend to have more dominant AGN-components in the mid-IR than typical SMGs, with a median AGN-fraction of 58%. Although, extrapolation to the far-IR reveals that the AGN is bolometrically unimportant in the majority of SMGs, indicating that the level of AGN contamination in the overall SMG population is probably $\lesssim 5\%$. For comparison, typical SMGs have $< 30\%$ AGN contribution in the mid-infrared, while they are from a very similar SB $L_{\rm IR}$ class to our sample of $\simeq 5 \times 10^{12}\,{\rm L}_{\odot}$.

- When literature sources are taken into account, a colour-selection of $S_8/S_{4.5} > 1.65$ is a better description overall for defining the boundary between SB and AGN-dominated SMGs, with a small amount of scatter across this division (see Fig. 1).
- Our results are thus consistent with the evolutionary scenario [4], with all SMGs undergoing a 'transitional' AGN-dominated phase with a duty cycle of $\simeq 20\%$. Our sample of AGN-dominated SMGs could be at a slightly later stage of evolution than SF-dominated SMG systems, with the SF still occurring but where the AGN has now begun to heat the dust appreciably in the SMG as the BH undergoes a period of rapid growth.

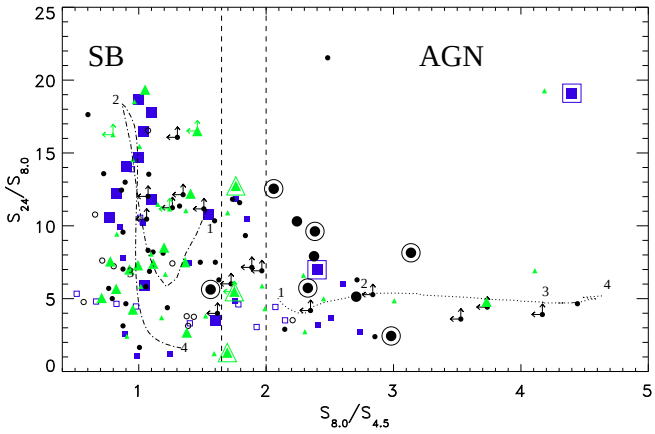

Figure 1: *Spitzer* colour-colour diagram as an AGN diagnostic for SMGs. Circles are SHADES SMGs, and other samples are plotted as squares [3] and triangles [2]. Mrk231 (an AGN; dotted line) and M82 (a SB; dot-dashed line) are plotted as a function of redshift for comparison. Sources with a $> 50\%$ contribution from continuum (AGN) emission to their mid-IR emission are **outlined** and tend to lie far from the M82 track.

ACKNOWLEDGMENTS

We would like to thank the conference organizers, STFC, NSF, NASA and the Royal Society for financial support, and also our collaborators from SHADES who contributed to this work. This work is based in part on observations made with the *Spitzer Space Telescope*, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA.

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